APPENDIX A:

HAZARD IDENTIFICATION AND ANALYSIS

Appendix A: Hazard Identification and Analysis

INTRODUCTION

This appendix identifies, describes and analyzes the natural hazards present in Hyde County that can threaten human life and damage property. It is broken down into the following three sections:

1. *Potential Hazards (includes descriptions and historical occurrences)*
2. *Hazard Profile Worksheet and Risk Index*
3. *Conclusions on Hazard Risk*

Appendix A: Hazard Identification and Analysis

1. POTENTIAL HAZARDS

Due to its unique geographical setting, Hyde County is vulnerable to a wide array of natural hazards that threaten life and property. These include:

- ✓ ***Flooding***
- ✓ ***Hurricanes***
- ✓ ***Tropical Storms***
- ✓ ***Coastal Storms including Nor'easters***
- ✓ ***Tornadoes***
- ✓ ***Severe Winter Storms***
- ✓ ***Severe Thunderstorms***
- ✓ ***Wildfires***
- ✓ ***Earthquakes***

Some of these hazards are interrelated (i.e., hurricanes can cause flooding and tornadoes), and some consist of hazardous elements that are not listed separately (i.e., severe thunderstorms can cause lightning; coastal storms can cause coastal erosion as well as damage to coastal inlets and channels). This section provides general descriptions for each of the above listed hazards along with their hazardous elements and provides information on historical hazard occurrences in Hyde County. Historical records are used to help us identify the level of risk, with the methodological assumption that the data sources cited are reliable and accurate.

1.A. FLOODING

Description:

Flooding is the most frequent and costly natural hazard in the United States. Floods are generally the result of excessive precipitation, and can be classified under two categories: *flash floods*, the product of heavy localized precipitation in short time period over a given location; and *general floods*, caused by precipitation over a longer time period and over a given river basin. The severity of a flooding event is determined by a combination of stream and river basin topography and physiography, precipitation and weather patterns, recent soil moisture conditions and the degree of vegetative clearing.

Flash flooding events usually occur within minutes or hours of heavy amounts of rainfall, from a dam or levee failure, or from a sudden release of water held by an ice jam. Most flash flooding is caused by slow-moving thunderstorms in a local area or by heavy rains associated with hurricanes and tropical storms. Although flash flooding occurs often along mountain streams, it is also common in urbanized areas where much of the ground is covered by impervious surfaces.

General floods are usually longer-term events and may last for several days. The primary types of general flooding include riverine flooding, coastal flooding and urban flooding. **Riverine flooding** is a function of excessive precipitation levels and water runoff volumes within the watershed of a stream or river. **Coastal flooding** is typically a result of storm surge, wind-driven waves, and heavy rainfall produced by hurricanes, tropical storms, nor'easters and other large coastal storms. **Urban flooding** occurs where man-made development has obstructed the natural flow of water and/or decreased the ability of natural groundcover to absorb and retain surface water runoff.

Periodic flooding of lands adjacent to rivers, streams and shorelines is a natural and inevitable occurrence that can be expected to take place based upon established recurrence intervals. The recurrence interval of a flood is defined as the average time interval, in years, expected between a flood event of a particular magnitude and an equal or larger flood. Flood magnitude increases with increasing recurrence interval.

A "floodplain" is the lowland area adjacent to a river, lake or ocean. Floodplains are designated by the frequency of the flood that is large enough to cover them. For example, the 10-year floodplain will be covered by the 10-year flood and the 100-year floodplain by the 100-year flood.

Flood frequencies, such as the "100-year flood," are determined by plotting a graph of the size of all known floods for an area and determining how often floods of a particular size occur. Another way of expressing the flood frequency is the chance of occurrence in a given year, which is the percentage of the probability of flooding each year. For example, the 100-year flood has a 1% chance of occurring in any given year.

Historical Occurrences:

Hyde County has been impacted by countless flood events, as over 90% of its area is determined to be in the 100-year floodplain. Most of these floods have occurred due to hurricanes, tropical storms, nor'easters and other coastal storms that produced storm surge, wind-driven waves, tidal flooding and heavy rainfall.

According to the National Climatic Data Center, Hyde County was impacted by the 4 major, non-tropical and non-winter storm related flood events between 1993 and 2008:

- *December 23, 1994:* A pressure gradient created by a double-barreled offshore low caused flooding due to the tidal surge. No major damages were recorded.
- *January 15, 1995:* Intense low pressure moving across the Southeastern United States produced storm force winds along the Outer Banks. Coastal flood warnings were in effect along the coast with seas running at 10 to 15 feet. Some sound-side flooding and beach erosion was reported.

- *September 8, 1995:* Huge swells generated by offshore Hurricane Luis pounded coastal sections with 8 to 10 foot seas. Approximately $500,000 in property damage was recorded.
- *May 8, 2007: Ocean overwash reported on Ocracoke Island. Some roads were flooded and closed in spots from high water. Strong low pressure developed off the NC coast on May 6th and drifted slowly south of the region on May 7th. Strong high pressure north of the area helped produce a very tight pressure gradient over the region with strong north to northeast winds. The prolonged period of strong northerly winds produced coastal flooding along the Outer Banks and areas adjacent to the southern Pamlico Sound.*

* Note: *This data does not include flood events associated with hurricanes, tropical storms and winter storms, as these events are listed within their respective sections that follow.*

1.B. HURRICANES & TROPICAL STORMS

Description:

Hurricanes and tropical storms, both classified as *tropical cyclones*, are low-pressure storm systems that originate over warm ocean waters but are capable of causing immense destruction when crossing the coastline into land. The primary damaging forces associated with these storms are high-level sustained winds, heavy precipitation and tornadoes. Coastal areas are also vulnerable to the additional forces of storm surge, wind-driven waves and tidal flooding.

The key energy source for a tropical cyclone is the release of latent heat from the condensation of warm water. Their formation requires a low-pressure disturbance, sufficiently warm sea surface temperature, rotational force from the spinning of the earth and the absence of wind shear in the lowest 50,000 feet of the atmosphere. Hurricanes and tropical storms can form in the Atlantic Ocean, Caribbean Sea and Gulf of Mexico from the months of June to November, but the peak of the Atlantic hurricane season is early to mid-September. The average number of storms that reach hurricane intensity per year in the Atlantic basin is about six.

As an incipient hurricane develops, barometric pressure at its center falls and **winds** increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, given a name and closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed 74 miles per hour, the storm is deemed a hurricane. Hurricane intensity is further classified by the Saffir-Simpson Scale, which rates hurricane intensity on a scale of 1 to 5, with 5 being the most intense. The Saffir-Simpson scale is shown in **Table A-1**.

TABLE A-1

Saffir-Simpson Scale			
Category	**Maximum Sustained Wind Speed (mph)**	**Minimum Surface Pressure (millibars)**	**Storm Surge (feet)**
1	74-95	Greater than 980	3-5
2	96-110	979-965	6-8
3	111-130	964-945	9-12
4	131-155	944-920	13-18
5	155+	Less than 920	19+

Source: National Hurricane Center

The Saffir-Simpson scale categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure and storm surge potential, which are combined to estimate potential damage. Categories 3, 4, and 5 are classified as "major" hurricanes, and while hurricanes within this range comprise only 20% of total tropical cyclone landfalls, they account for over 70% of the damage in the U.S. **Table A-2** describes the damage that could be expected for each category hurricane.

TABLE A-2

Hurricane Damage Classification		
Category	**Damage Level**	**Description**
1	MINIMAL	No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also, some coastal flooding and minor pier damage.
2	MODERATE	Some roofing material, door, and window damage. Considerable damage to vegetation, mobile homes, etc. Flooding damages piers and small craft in unprotected moorings may break their moorings.
3	EXTENSIVE	Some structural damage to small residences and utility buildings, with a minor amount of curtainwall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures with larger structures damaged by floating debris. Terrain may be flooded well inland.
4	EXTREME	More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain may be flooded well inland.
5	CATASTROPHIC	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas may be required.

Source: National Hurricane Center

A **storm surge** is a large dome of water often 50 to 100 miles wide and rising anywhere from 4 to 5 ft in a category 1 hurricane up to 20 ft in a category 5 storm. The storm surge arrives ahead of the storm's actual landfall and the more intense the hurricane is, the sooner the surge arrives. Water rise can be very rapid, posing a serious treat to those who have waited to evacuate flood prone areas. A storm surge is a wave that has outrun its generating source and become a long period swell. The surge is always highest in the right-front quadrant of the direction the hurricane is moving in. As the storm approaches shore the greatest storm surge will be to the north of the hurricane eye.

Such a surge of high water topped by waves driven by hurricane force winds can be devastating to coastal regions, causing severe **beach erosion** and property damage along the immediate coast. The stronger the hurricane and the shallower the offshore water, the higher the surge will be. In addition, if the storm surge arrives at the same time as the high tide, the water height will be even greater. The storm tide is the combination of the storm surge and the normal astronomical tide.

Damage during hurricanes may also result from **spawned tornadoes** and **inland flooding** associated with heavy rainfall that usually accompanies these storms. Hurricane Floyd, for example, was at one time a Category 4 hurricane racing towards the North Carolina coast. As far inland as Raleigh, the state capital located more than 100 miles from the coast, communities were preparing for extremely damaging winds exceeding 100 miles per hour. However, Floyd made landfall as a Category 2 hurricane and will be remembered for causing the worst inland flooding disaster in North Carolina's history. Rainfall amounts were as high as 20 inches in certain locales, and sixty-seven counties sustained damages.

Historical Occurrences:

North Carolina has a long and notorious history of destruction by hurricanes. Ever since the first expeditions to Roanoke Island in 1586, hurricanes are recorded to have caused tremendous damage to the state. The state's protruding coastline makes it a favorable target for tropical cyclones that curve northward in the western Atlantic Ocean.

Reliable classification of the intensity of tropical cyclones began in 1886. Since that time, there have been 951 tropical cyclones that have been recorded in the Atlantic Ocean and the Gulf of Mexico. Approximately 166 or 17.5% of those tropical cyclones passed within 300 miles of North Carolina.

According to the State Climate Office of North Carolina, 38 tropical cyclones have made direct landfall in North Carolina since 1886. Of these, 10 were tropical storms, 22 were minor hurricanes and 6 were major hurricanes. Another 56 tropical cyclones have impacted North Carolina since 1886 by either entering from another state or by passing in proximity to the coast but remaining offshore. Of these, 41 were tropical storms, 8 were minor hurricanes and 7 were major hurricanes. According to the State Climate Office, the coast of North Carolina can expect to receive a landfalling tropical cyclone once every four years and be affected by one every 1.3 years.

Table A-3 lists all hurricanes and tropical storms that have made direct landfall in North Carolina since 1800. Approximate location of landfall and estimated wind speed and storm surge at landfall are also listed.

TABLE A-3

Direct Landfalling Hurricanes and Tropical Storms in North Carolina Since 1886

Note: This list does not count storms that made landfall in another state, then moved into North Carolina. The list of other storms that affected North Carolina is provided in Table A-5.

Approximate Date of Landfall	Storm Name	Saffir-Simpson Intensity at Landfall	Approximate Location of Landfall	Estimated Wind Speed (kt)	Storm Surge (ft.)
9/18/2003	Isabel	2	Drum Inlet	90	6-8
9/16/1999	Floyd	2	Topsail Island	95	
9/4/1999	Dennis	Tropical Storm	Core Banks	60	
8/26/1998	Bonnie	3	Cape Fear	100	6-8
9/6/1996	Fran	3	Cape Fear	100	8-12
7/13/1996	Bertha	2	Topsail Beach	90	5
6/20/1996	Arthur	Tropical Storm	Morehead	35	
8/18/1986	Charley	1	Morehead	70	
9/26/1985	Gloria	2	Hatteras	90	6-8
9/9/1984	Diana	1	Long Beach	80	5-6
9/30/1971	Ginger	1	Atlantic Beach	65	4
8/27/1971	Doria	Tropical Storm	Atlantic Beach	55	
10/16/1964	Isabell	1	Morehead	65	
9/11/1960	Donna	2	East of Wilmington	95	6-8
9/19/1955	Ione	2	Salter Path	90	3-10
8/17/1955	Diane	1	Carolina Beach	75	5-9
8/12/1955	Connie	1	Cape Lookout	70	7
10/15/1954	Hazel	4	NC/SC border	125	10-20
8/30/1954	Carol	2	Hatteras	85	
8/13/1953	Barbara	2	Cape Lookout	90	
7/6/1946		Tropical Storm	Wilmington	60	
6/25/1945		Tropical Storm	Hatteras	55	
8/1/1944		1	Southport	80	
9/18/1936		2	Hatteras	85	
9/16/1933		3	Ocracoke	100	
8/23/1933		2	Hatteras	85	

12/2/1925		1	Wilmington/ Hatteras	65	
9/22/1920		1	Topsail Beach	65	
8/25/1918		Tropical Storm	Morehead	50	
9/6/1916		Tropical Storm	Southport	35	
9/3/1913		1	Hatteras	70	10
7/31/1908		2	Morehead	85	
11/13/1904		3	Hatteras	100	
7/11/1901		1	Hatteras	65	
10/13/1900		Tropical Storm	Hatteras		
10/31/1899		1	Wrightsville Beach	80	8
8/16/1899		4	Hatteras	115	4-10
10/26/1897		Tropical Storm	North of Hatteras	55	
10/22/1893		Tropical Storm	West of Hatteras	50	

Source: State Climate Office of North Carolina, 2001

Table A-4 lists all hurricanes and tropical storms that made landfall in another state and later passed through North Carolina. Maximum levels of intensity and estimated wind speed are also listed.

TABLE A-4

Hurricanes and Tropical Storms that have Affected North Carolina Since 1886

Date Storm Affected NC	Name	Saffir-Simpson Maximum Intensity in North Carolina	Estimated Maximum Wind Speed (kt)
8/3/04	Alex*	2*	85
10/8/1996	Josephine	Extratropical	45
6/6/1995	Allison	Extratropical	40
8/31/1993	Emily	3*	100
9/25/1992	Danielle	Tropical Storm*	45
8/19/1991	Bob	3*	100
9/22/1989	Hugo	3	100
8/29/1988	Chris	Depression	20
11/22/1985	Kate	Tropical Storm	45
7/25/1985	Bob	Tropical Storm	45
8/20/1981	Dennis	Tropical Storm	55
9/5/1979	David	Tropical Storm	40
8/9/1976	Belle	Tropical Storm*	50
6/21/1972	Agnes	Tropical Storm	40
9/10/1969	Gerda	Tropical Storm*	35
10/20/1968	Gladys	1*	70
9/16/1967	Doria	Tropical Storm	45
8/29/1962	Alma	1*	65
9/27/1958	Helene	3*	110

9/11/1954	Edna	Tropical Storm*	60
8/31/1952	Able	Tropical Storm	45
8/20/1950	Able	4*	115
8/28/1949		Tropical Storm*	40
8/24/1949		1*	65
10/12/1947		Tropical Storm	40
10/9/1946		Extratropical	25
9/17/1945		Tropical Storm	40
10/20/1944		Tropical Storm	40
9/14/1944		3*	110
8/11/1940		Tropical Storm	40
9/21/1938		Tropical Storm*	60
9/5/1935		Tropical Storm	40
9/8/1934		Tropical Storm*	60
9/12/1930		1 *	65
10/1/1929		Tropical Storm*	40
9/18/1928		Tropical Storm	40
8/25/1924		1*	65
7/19/1916		Tropical Storm*	45
7/14/1916		Tropical Storm	55
10/19/1910		Tropical Storm*	35
8/31/1908		Tropical Storm*	45
7/30/1908		Tropical Storm*	55
9/17/1906		3	100
9/14/1904		Tropical Storm	60
9/15/1903		1	65
10/2/1898		Tropical Storm	40
10/20/1897		Tropical Storm*	40
9/22/1897		Tropical Storm*	45
9/29/1896		Depression	30
10/10/1894		Tropical Storm	50
9/28/1894		Tropical Storm	55
8/28/1893		1	70
8/23/1893		Tropical Storm	60
6/16/1893		Tropical Storm	50
9/24/1889		Tropical Storm	60
9/11/1889		Tropical Storm*	60
11/25/1888		Tropical Storm*	60
10/11/1888		Tropical Storm	55
10/31/1887		Tropical Storm*	60
10/20/1887		Extratropical	30
8/20/1887		1*	85
6/30/1886		Tropical Storm	40
6/20/1886		Tropical Storm	30

* indicates that the storm passed off the coast

Source: State Climate Office of North Carolina, 2001

According to the National Weather Service, Hurricane Isabel occurring in 2003, is directly responsible for 16 deaths: 10 in Virginia, and 1 each in North Carolina, Maryland, New Jersey, New York, Rhode Island, and Florida. The deaths in Florida and Rhode Island were drownings in high surf generated by Isabel. Isabel was indirectly responsible for 34 deaths: 22 in Virginia, 6 in Maryland, 2 in North Carolina and Pennsylvania, and 1 each in New Jersey and the District of Columbia.

Isabel caused widespread wind and storm surge damage in coastal eastern North Carolina and southeastern Virginia. Storm surge damage also occurred along Chesapeake Bay and the associated river estuaries, while wind damage occurred over portions of the remaining area from southern Virginia northward to New York. The current estimate for insured property damage is $1.685 billion - $925 million in Virginia, $410 million in Maryland, $170 million in North Carolina, $80 million in Pennsylvania, $45 million in New York, $25 million in New Jersey, $20 million in Delaware, and $10 million in West Virginia. The total damage for Isabel is estimated to be about twice that of the insured damage, or $3.37 billion.

1999 saw the most costly hurricane to ever hit North Carolina, **Hurricane Floyd**. Hurricane Floyd made landfall as a Category two storm near Topsail Island and its progression inland resulted in unprecedented, widespread flooding across eastern North Carolina. Damage from Floyd was worse than might have been expected because of Hurricane Dennis, which had dropped as much as 8 inches of rain on eastern North Carolina just 10 days earlier. Rainfall amounts for Floyd were as high as 15 to 20 inches, and rivers across North Carolina rose as much as 23 feet above flood stage, shattering previously established flood records for many locales. Sixty-seven counties sustained damages, and there were a total 52 deaths. In total, the storm damaged more than 55,000 homes, 17,000 of which were left uninhabitable and another 7,000 destroyed. Total damage estimates exceed 6 billion dollars.

1996 was a rare year in the hurricane history of North Carolina. Tropical Storm Arthur, Hurricane Bertha, and Hurricane Fran all made direct landfall on the North Carolina coastline. It was the most active tropical cyclone season in the state since 1955, when Hurricanes Connie, Diane, and Ione all hit the coast. **Hurricane Fran** was especially destructive. Fran struck the coast as a Category three storm at Cape Fear, causing widespread damages and impacting sixty percent of the state. Flash flooding in the mountains, high winds and riverine flooding in the Piedmont and Coastal Plain, and a coastal storm surge of up to 12 feet took a heavy toll on residences, businesses and agriculture. The storm was responsible for 24 deaths and damaged more than 40,000 homes. Total damage estimates exceed 3.2 billion dollars.

1953, 1954, and 1955 was the most active three-year period of tropical cyclones in the state's history. Over that period, six hurricanes made direct landfall in North Carolina. The most powerful hurricane to hit the state made landfall in 1954, **Hurricane Hazel**. It was the only category 4 hurricane to make landfall in North Carolina during the last century, resulting in 95 deaths and 2.8 million dollars in damages.

According to the National Climatic Data Center, Hyde County was impacted by 12 hurricanes and 7 tropical storms between 1993 and 2008. These events are listed below along with information on damages for the Hyde County region (warning areas as determined by the National Climatic Data Center).

- *November 17, 1994:* Hurricane Gordon remained offshore, but caused significant flooding and strong winds all along the central and northern North Carolina coast. Approximately $500,000 in property damage was recorded.
- *August 15, 1995:* Hurricane Felix came within 200 miles of Cape Hatteras, stalled for several hours, and then drifted north and east away from the coast. Highway 12 began flooding on the 16th and continued sporadically through the 20th. Minor structural damage was reported on the Outer Banks. One fatality was recorded, along with approximately $500,000 in property damage and $500,000 in crop damage.
- *June 18, 1996:* Tropical Storm Arthur teased the North Carolina coast, moving parallel to the coast and then up across Cape Lookout into the Pamlico Sound where it was downgraded to a tropical depression. Heavy rains fell across the region accompanied by heavy surf. Approximately $1 million in property damage and minor crop damage was recorded.
- *July 12, 1996:* Hurricane Bertha slammed into the North Carolina coastline between Surf City and North Topsail Beach causing severe damage to property, utilities and roads. Peak wind gusts of 108 mph and a storm surge of 8-10 feet were recorded, and as much as 8 inches or rain fell across the region. One fatality and 10 injuries were recorded, along with approximately $1.43 million in property damage and $1.27 million in crop damage.
- *September 6, 1996:* Hurricane Fran, a Category 3 hurricane, moved onshore near Cape Fear and raced north toward Raleigh cutting a swath of destruction. Wind gusts over 100 mph and storm surges of over 10 feet were recorded. Four fatalities and four injuries were recorded, along with approximately $792 million in property damage.
- *October 8, 1996:* The remnants of Tropical Storm Josephine moved up the Eastern Seaboard and across eastern North Carolina dumping as much as much as 6 inches of rain. No major damages were recorded for this event, and according to the Hyde County Building Inspector there was no rain at all in Hyde County.

- *August 28, 1996:* Hurricane Bonnie approached the coast of North Carolina as a minimal Category 3 hurricane, but quickly weakened to Category 1 storm before making landfall near the Onslow/Pender county line. The storm then continued to move slowly northeast at speeds of 10 mph or less, dumping 7-10 inches of rain across eastern North Carolina. Since much of the region had experienced below normal rainfall during the summer months, the resulting flood was not as damaging as it could have been. Only minor injuries were recorded, along with approximately $6.4 million in property damage and $117 million in crop damage.
- *August 30, 1999:* Hurricane Dennis, a minimal Category 2 hurricane approached the coast of North Carolina but was quickly downgraded to a tropical storm. Tropical Storm Dennis was drifting at 4 mph and would remain in this quasi-stationary position for the next few days… only to return to eastern North Carolina and make landfall on September 4th along the Core Banks just north of Cape Lookout (see next event). For most counties, Hurricane Dennis left relatively little in its wake although on the Outer Banks beach erosion and the storm tide effects were extreme.
- *September 4, 1999:* Tropical Storm Dennis made landfall along the Core Banks and continued very slowly through eastern North Carolina dumping very heavy rains. Ocean storm surges were 2 to 3 feet above normal, and along the Neuse and Pamlico Rivers storm tides were about 6 to 8 feet above normal. Approximately $21.3 million in property damage and $39.9 million in crop damage was recorded (combined totals for Hurricane Dennis and Tropical Storm Dennis).
- *September 16, 1999:* Hurricane Floyd caused massive record flooding across inland sections of eastern North Carolina and will be categorized as one of the nation's most costly hurricanes in the 20th century. Floyd made landfall near North Topsail Beach as a Category 2 hurricane, moving northeast and continuing over the eastern shores of Virginia. As the hurricane moved over the eastern coast of North Carolina, it accelerated and weakened. Ocean storm surges were about 4 to 6 feet above normal...generally affecting Onslow, Carteret and Hyde Counties. This caused extensive beach erosion on the south facing beaches. Ocracoke Island officials reported at least 10 new dune breaks along Highway 12 and the Pamlico River storm tides were around 6 to 8 feet above normal. Water levels were especially high in Hyde County, including Swan Quarter, Sladesville and Scranton. At least 13 fatalities were reported for the 15-county warning area that included Hyde County, along with approximately $410.6 million in property damage and $413.6 million in crop damage.
- *October 16, 1999:* Hurricane Irene, a Category 1 hurricane, paralleled the coast of eastern North Carolina. Since the eye remained offshore so did the hurricane force winds. In turn, storm surges were insignificant. Very minor beach erosion was experienced along the beaches in Onslow County and along Bogue Banks in Carteret County. The highest offshore wind was 67 mph and the peak inland wind reported was 47 mph at Cape Hatteras/Frisco. Rainfall again played the largest role during the event, with estimates ranging from 4 to 6 inches with isolated areas receiving 8 to 10 inches. No significant was caused by this event.

- *September 10, 2002:* **Tropical Storm Gustav** passed just offshore of the Outer Banks of North Carolina on September 10th. Winds up to 78 mph were reported by the Coastal Guard at Cape Hatteras, 74mph were recorded at Ocracoke and 60 mph were recorded at Cedar Island. Storm surge of 4 feet occurred at Cedar Island where Ocracoke and Hatteras Village experienced a surge of 5 to 6 feet with the strong northwest winds. Portions of Highway 12 from Rodanthe south to Ocracoke were over washed by 10 to 15 foot ocean swells. Minor flooding damage was reported in several businesses in and around Ocracoke and Hatteras Village.
- *September 17, 2003*: **Hurricane Isabel** made landfall early in the afternoon on September 18th as a category two hurricane across Core Banks in extreme eastern Carteret county. Isabel moved north northwest near 20 mph across eastern North Carolina during the afternoon. Areas mainly near and east of the storm center experienced significant wind and storm surge effects. Major ocean overwash and beach erosion occurred along the North Carolina Outer Banks where waves up to 20 feet accompanied a 6 to 8 foot storm surge. Almost 350 million dollars in damage occurred in Dare county alone where several thousand homes and businesses, several piers, and sections of Highway 12 were damaged or washed away. Eastern Carteret, eastern Pamlico, southern Craven, Beaufort, and Hyde counties experienced significant storm surge damage with hundreds of homes flooded in most of these counties. The highest storm surges were experienced in the lower reaches of the Neuse River where water levels rose to as high as 10.5 feet at the mouth of Adams Creek. Storm surge values ranged from 6 to 10 feet across eastern Pamlico county with the highest water levels recorded near Oriental. A 4 to 7 foot storm surge occurred across Core Sound in eastern Carteret county, except water levels rose between 8 and 10 feet along the South River and Big Creek. Storm surge values were around 7 feet in portions of Beaufort county in Washington, and Belhaven. Virtually every business on Main Street in Belhaven was flooded with 2 to 3 feet of water. Storm surges from 2 to 6 feet occurred across Hyde county with the highest water levels recorded in Swan Quarter in the southwest part of the county where hundreds of homes and businesses flooded. Wind damage was more significant across Hyde, Washington, Tyrell, Martin, and the Outer Banks counties where wind gusts of around 100 mph occurred. Hurricane force winds resulted in structural damage to homes. Numerous trees and power lines were downed across these areas resulting in a loss of electricity for several weeks in some locations. Hurricane force winds were also experienced in parts of the inland counties of Jones, Craven, and Pitt counties during the afternoon of September 18th where inland hurricane wind warnings had been in effect for 11 hours. Other counties west of the center of the storm experienced wind gusts between 60 and 65 mph.
- *August 3, 2004:* **Hurricane Alex**, a category two storm with 100 mph sustained winds, brushed the Outer Banks of North Carolina during the late morning to early afternoon hours on August 3rd. The most significant impacts occurred along the Outer Banks from Ocracoke to Buxton where winds gusted to near 100 mph and soundside flooding was estimated between 4 to 6 feet. Winds and storm surge resulted in damage to over 100 homes and businesses. Nearly 500 cars were completely flooded on Ocracoke, and in the Hatteras Village area with damage estimated near 7.5 million dollars. Storm surge along the coast, along

the lower reaches of the Neuse and Pamlico Rivers, and across other counties adjacent to the Pamlico and Albemarle Sounds were estimated at 1 to 3 feet where no significant damage occurred. The first outer rainbands began affecting the area during the early morning hours and continued through the day. Four to eight inches of rainfall was estimated across eastern Craven and Carteret Counties extending northeast and including Dare and Hyde counties. Freshwater flooding was reported across Craven and Carteret Counties. There were no reported tornadoes.

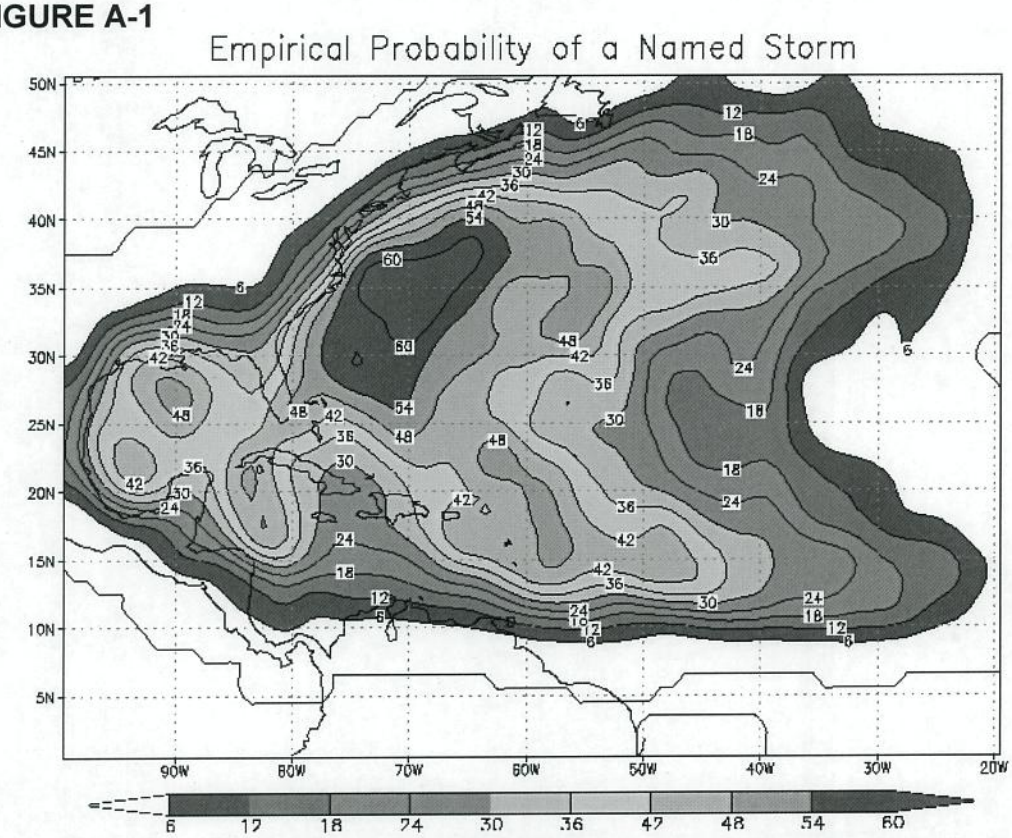
- *August 14, 2004*: **Tropical Storm Charley** moved northeast across the Coastal Plains of Eastern North Carolina during the afternoon hours on August 14th. Onslow county received the most damage, with estimates over 5 million dollars, as winds gusted to near hurricane force toppling trees and power lines with structural damage to homes and businesses. Winds gusted from 60-70 mph across Inland areas near the center of the storm resulting in wind damage to structures, and damage to crops reaching into the millions. Winds gusted from 40 to 50 mph across locations across Eastern North Carolina with minor wind damage reported. Storm surge values were highest along the Onslow County coastline where a 2 to 3 foot surge was estimated, and 8 foot waves caused minor beach erosion along the south facing beaches. Water levels rose up to 2 feet across the lower reaches of the Neuse and the Pamlico Rivers, and across the Outer Banks. Storm total rainfall, estimated between 4 to 6 inches, occurred across a large part of the area resulting in freshwater flooding in 7 counties across the Coastal Plains. Five weak tornadoes were reported across the area associated with Charley with damage reported. The most significant damage related to a tornado occurred along the Outer Banks in Nags Head.
- *September 13, 2005*: Category one **Hurricane Ophelia**, with maximum sustained winds of 85 mph, approached the North Carolina coast on the 13th. The hurricane remained offshore brushing the southern coastal counties of Onslow and Carteret on the 14th and 15th. Highest winds and damages occurred across this area where winds gusted to near 100 mph, and storm surges of up to 6 feet resulted in structural damages totaling near 35 million dollars. The highest surge was reported along the lower reaches of the Neuse River in southern Craven County where water levels rose to 8 feet, during the night of the 14th. Ophelia brushed by Outer Banks Hyde and Dare counties on the 16th with hurricane force wind gusts, primarily across coastal Hyde county where minor flooding and structural damage occurred. Minor wind damage occurred across the inland counties of Duplin, Jones, Lenoir, and Craven where tropical storm force wind gusts blew shingles off roofs, and downed trees and power lines. The combination of surge from Pamlico Sound and heavy storm total rainfall, from 4 to 9 inches, resulted in the flooding of streams, roads, and lower elevations in Beaufort, Carteret, Craven, Jones, Onslow, and Pamlico counties.
- *August 31, 2006*: **TROPICAL STORM ERNESTO**, WITH MAXIMUM SUSTAINED WINDS OF 70 MPH, MADE LANDFALL ON AUGUST 31ST DURING THE LATE EVENING HOURS. THE STRONG TROPICAL STORM MOVED ACROSS THE COASTAL PLAINS REGION DURING THE EARLY MORNING HOURS ON FRIDAY SEPTEMBER 1ST. IN GENERAL, WIND GUSTS RANGED FROM 40 TO 60 MPH WITH THE HIGHEST GUSTS NEAR 70 MPH ALONG THE COASTAL SECTIONS OF ONSLOW COUNTY. MINOR

STORM SURGE FLOODING AND BEACH EROSION OCCURRED ALONG THE ONSLOW AND CARTERET COUNTY COAST LINE AND THE NEUSE RIVER. MORE SIGNIFICANT SURGE OCCURRED ALONG THE PAMLICO RIVER IN BEAUFORT COUNTY WHERE EVACUATIONS WERE ORDERED. STORM TOTAL RAINFALL RANGED FROM 4 INCHES TO NEAR 10 INCHES. THIS HEAVY RAINFALL RESULTED IN EXTENSIVE FRESH WATER FLOODING AND EVENTUAL RIVER FLOODING ACROSS THE AREA WITH SOME PRIMARY AND MANY SECONDARY ROADS FLOODED. THE NORTHEAST CAPE FEAR RIVER AT CHINQUAPIN REMAINED IN MAJOR FLOOD FROM SEPTEMBER 2ND THROUGH SEPTEMBER 7TH RESULTING OF FLOODING OF PRIMARY ROADS AND HOMES FORCING THE EVACUATION OF MANY RESIDENTS IN THE CHINQUAPIN AREA. HEAVY RAINFALL DURING THE EVENING OF AUGUST 31ST THROUGH THE EARLY MORNING HOURS OF SEPTEMBER 1ST RESULTED IN EXTENSIVE FLOODING OF LOW LYING AREAS, ROADS, AND STREAMS ACROSS EASTERN NORTH CAROLINA, MAINLY WEST OF THE HIGHWAY 17 CORRIDOR. AREAL FLOOD WARNINGS WERE ISSUED FOR MOST OF THE COUNTY WARNING AREA AS ERNESTO MOVED ACROSS THE COASTAL PLAINS COUNTIES OF EASTERN NORTH CAROLINA. DUPLIN COUNTY WAS HARDEST HIT WITH PRIMARY ROADS FLOODED INCLUDING A 12 MILE STRETCH OF INTERSTATE 40. MANY STREAMS AND ROADS ACROSS THE COASTAL PLAINS COUNTIES REMAINED FLOODED FOR SEVERAL DAYS. FRESHWATER FLOODING AND RIVER FLOODING FROM ERNESTO CAUSED MOST OF THE DAMAGES ACROSS EASTERN NORTH CAROLINA. THE MOST SIGNIFICANT STORM SURGE EFFECTS OCCURRED ALONG THE PAMLICO AND PUNGO RIVERS IN BEAUFORT COUNTY WHERE ESTIMATED WATER LEVEL RISES OF 4 TO 6 FEET RESULTED IN FLOODING OF MANY ROADS, LOW LYING AREAS, HOMES, AND BUSINESSES IN WASHINGTON, WHICHARDS BEACH, AND BELHAVEN. HIGHEST WIND GUSTS OCCURRED IN THE COASTAL PLAINS COUNTIES WITH GUSTS NEAR 70 MPH ALONG COASTAL ONSLOW COUNTY WITH WIND DAMAGE REPORTED. THIRTY HOMES AND BUSINESSES WERE DAMAGED, MAINLY FROM FRESHWATER FLOODING, IN ONSLOW COUNTY WITH DAMAGES ESTIMATED NEAR 1/2 MILLION DOLLARS. THIRTY HOMES WERE FLOODED OR REPORTED WIND DAMAGE IN JONES COUNTY WITH DAMAGE ESTIMATES OVER ONE HUNDRED THOUSAND DOLLARS. CROP DAMAGE IN JONES COUNTY WAS ESTIMATED UP TO 5 MILLION DOLLARS. FRESHWATER FLOODING WAS EXTENSIVE IN DUPLIN COUNTY, AND MAJOR RIVER FLOODING OCCURRED ALONG THE NORTHEAST CAPE FEAR RIVER NEAR CHINQUAPIN WHERE SEVERAL PRIMARY AND MANY SECONDARY ROADS WERE FLOODED FOR NEARLY ONE WEEK. EVACUATIONS OF MANY HOMES, AND RESCUES DUE TO HIGH WATER WERE REQUIRED ACROSS SEVERAL LOCATIONS ACROSS THE COUNTY, ESPECIALLY NEAR CHINQUAPIN. AN ESTIMATED SOUNDSIDE FLOODING OF 3 FEET OCCURRED AT COLLINGTON HARBOR IN DARE COUNTY WHERE SEVERAL HOMES AND BUSINESSES WERE FLOODED WITH AN ESTIMATED FIFTY THOUSAND DOLLARS IN DAMAGES OCCURRED. MINOR WIND OR FLOODING DAMAGES WERE REPORTED IN MANY OTHER COUNTIES IN EASTERN NORTH CAROLINA.

Figure A-1 shows for any particular location what the chance is that a tropical storm or hurricane will affect the area sometime during the whole June to November hurricane season. The figure was created by Todd Kimberlain of the National Oceanic and Atmospheric Administration's Hurricane Research Division. In creating the graphic, he utilized the years 1944 to 1999 in the analysis and counted hits when a storm or hurricane was within about 100 miles (165 km) of each location.

The figure shows that Hyde County faces a **36-48% annual chance** that a tropical storm or hurricane will affect the area.

FIGURE A-1



Source: National Oceanic and Atmospheric Administration, Hurricane Research Division

1.C. TORNADOES

Description:

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. It is most often generated by a thunderstorm (but sometimes result from hurricanes or nor'easters) and produced when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. The damage from a tornado is a result of the high wind velocity and wind-blown debris, although they are commonly accompanied by large hail as well. The most violent tornadoes have rotating winds of 250 miles per hour or more and are capable of causing extreme destruction, including uprooting trees and well-made structures, and turning normally harmless objects into deadly missiles.

Most tornadoes are just a few dozen yards wide and touch down only briefly, but highly destructive tornadoes may carve out a path over a mile wide and several miles long. The destruction caused by tornadoes may range from light to inconceivable depending on the intensity, size and duration of the storm. Typically, tornadoes cause the greatest damages to structures of light construction, such as residential homes, and are quite localized in impact. Each year an average of 800-1000 tornadoes are reported nationwide, and they are more likely to occur during the spring and early summer months of March through June. Tornadoes can occur at any time of day but are mostly likely to form in late afternoons and early evenings.

The Fujita-Pearson Scale for Tornadoes was developed to measure tornado strength, and is shown in **Table A-5**.

TABLE A-5

Fujita-Pearson Scale for Tornadoes			
F-Scale Number	**Intensity Phrase**	**Wind Speed**	**Type of Damage Done**
F0	Gale tornado	40-72 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages to sign boards.
F1	Moderate tornado	73-112 mph	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
F2	Significant tornado	113-157 mph	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
F3	Severe tornado	158-206 mph	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
F4	Devastating tornado	207-260 mph	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
F5	Incredible tornado	261-318 mph	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel re-enforced concrete

			structures badly damaged.
F6	Inconceivable tornado	319-379 mph	These winds are very unlikely. The small area of damage they might produce would probably not be recognizable along with the mess produced by F4 and F5 wind that would surround the F6 winds. Missiles, such as cars and refrigerators would do serious secondary damage that could not be directly identified as F6 damage. If this level is ever achieved, evidence for it might only be found in some manner of ground swirl pattern, for it may never be identifiable through engineering studies.

Source: The Tornado Project

Historical Occurrences:

There have been 1066 confirmed tornadoes in North Carolina since 1950. Typically, North Carolina tornadoes are less severe than in other parts of the country. Compared with other States, North Carolina ranks number 22nd for frequency of tornadoes, 20th for number of deaths, 17th for injuries and 21st for cost of damages.
According to the National Climatic Data Center, there have been 19 confirmed tornado events in Hyde County since 1950, which have resulted in zero deaths, 4 injuries and approximately $1.5 million in property damages. These events include waterspouts, which are simply tornadoes over water. The strongest tornado ever recorded in Hyde County is an F2, which occurred on two separate occasions (1952 and 1986).

Table A-6 lists all tornado events reported for Hyde County between 1950 and June 1, 2008.

TABLE A-6

Tornadoes and Waterspouts in Hyde County (1950 – Sept. 30, 2001)							
Location	**Date**	**Time**	**Type**	**Magnitude**	**Deaths**	**Injuries**	**Property Damage**
Rose Bay	8/14/2004	2:40 PM	Tornado	F0	0	0	0
Ocracoke	9/10/2002	11:05 AM	Tornado	F0	0	0	1K
Swan Quarter	9/15/1999	6:25 PM	Tornado	F0	0	0	0
Ocracoke	9/3/1998	9:45 PM	Tornado	F1	0	0	200K
Swan Quarter	7/26/1998	10:30 AM	Waterspout	N/A	0	0	0
Ocracoke	7/1/1998	8:37 PM	Waterspout	N/A	0	0	20K
New Holland	5/8/1998	4:49 PM	Funnel Cloud	N/A	0	0	0
Ocracoke	7/23/1997	8:38 AM	Waterspout	N/A	0	0	0
Engelhard	8/6/1993	2:45 PM	Tornado	F0	0	0	5K
Swan Quarter	8/6/1993	2:10 PM	Tornado	F1	0	0	500K

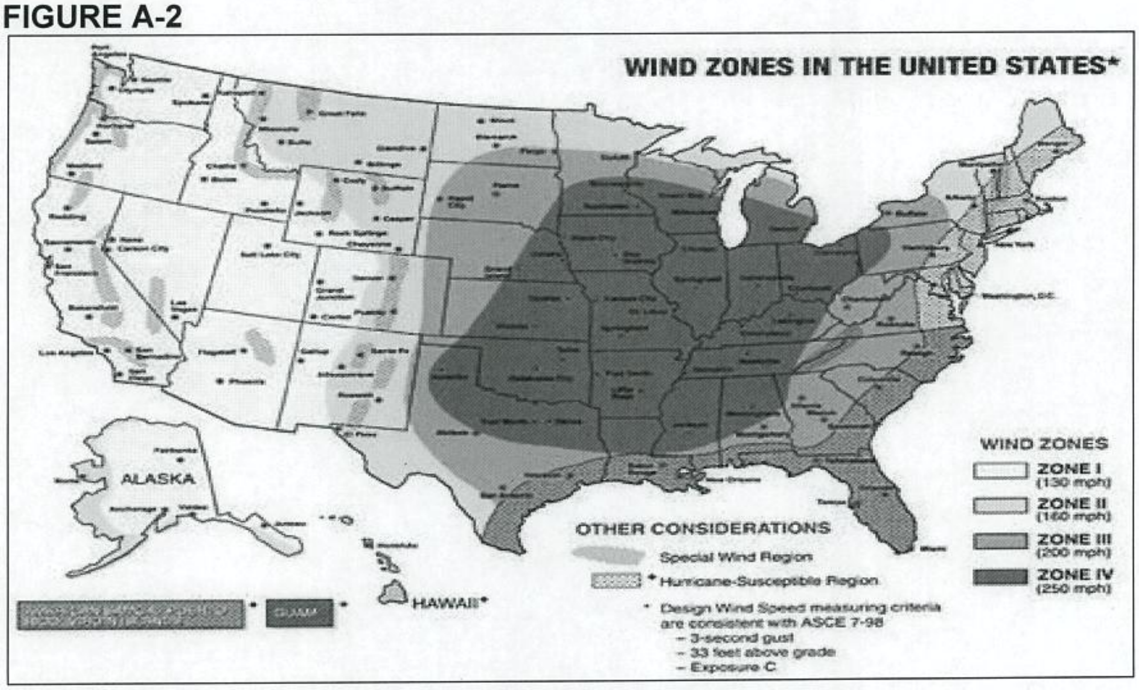
Ponzer	8/6/1993	2:00 PM	Tornado	F1	0	0	50K
Hyde County	6/21/1992	11:45 AM	Tornado	F0	0	0	0K
Hyde County	11/28/1988	3:09 AM	Tornado	F1	0	1	250K
Hyde County	6/20/1986	1:35 PM	Tornado	F0	0	0	0K
Hyde County	6/17/1986	3:45 PM	Tornado	F2	0	0	250K
Hyde County	6/17/1986	3:30 PM	Tornado	F0	0	0	3K
Hyde County	11/4/1985	8:12 AM	Tornado	F0	0	0	3K
Hyde County	3/21/1983	6:10 AM	Tornado	F1	0	0	250K
Hyde County	3/18/1956	5:00 PM	Tornado	F1	0	1	25K
Hyde County	5/20/1952	11:00 AM	Tornado	F2	0	2	0K
TOTAL					0	4	1.555M

Source: National Climatic Data Center

Figure A-2 shows the shows how the frequency and strength of extreme windstorms vary across the United States. This map was produced by the Federal Emergency Management Agency and is based on 40 years of tornado history and over 100 years of hurricane history. Zone IV, the darkest area on the map, has experienced both the greatest number of tornadoes and the strongest tornadoes. As shown by the map key, wind speeds in Zone IV can be as high as 250 mph.

Hyde County is located within Zone III. The tornado hazard in Zone III, while not as great as in Zone IV, is still significant with winds potentially reachin 200 miles per hour. In addition, Zone III includes coastal areas which are susceptible to hurricanes.

FIGURE A-2



Source: Federal Emergency Management Agency

1.D. NOR'EASTERS And Coastal Storms

Description:

Similar to hurricanes, nor'easters are ocean storms capable of causing substantial damage to coastal areas in the eastern United States due to their associated strong winds and heavy surf. Nor'easters are named for the winds that blow in from the northeast and drive the storm up the east coast along the Gulf Stream, a band of warm water that lies off the Atlantic coast. They are caused by the interaction of the jet stream with horizontal temperature gradients, and generally occur during the fall and winter months when moisture and cold air are plentiful.

Nor'easters are known for dumping heavy amounts of **rain and snow**, producing hurricane-force **winds**, and creating high surfs that cause severe **beach erosion** and **coastal flooding**. There are two main components to a Nor'easter: (1) a Gulf Stream low-pressure system (counter-clockwise winds) generated off the southeastern U.S. coast, gathering warm air and moisture from the Atlantic, and pulled up the east coast by strong northeasterly winds at the leading edge of the storm; and (2) an Arctic high-pressure system (clockwise winds) which meets the low-pressure system with cold, Arctic air blowing down from Canada. When the two systems collide, the moisture and cold air produce a mix of precipitation and have the potential for creating dangerously high winds and heavy seas.

As the low-pressure system deepens, the intensity of the winds and waves will increase and cause serious damage to coastal areas as the storm generally moves northeast. Davis and Dolan (1993) have proposed an intensity scale for nor'easters that is based upon levels of coastal degradation, which is shown in **Table A-7**.

TABLE A-7

The Dolan-Davis Nor'easter Intensity Scale				
Storm Class	**Beach Erosion**	**Dune Erosion**	**Overwash**	**Property Damage**
1 (Weak)	Minor changes	None	No	No
2 (Moderate)	Modest; mostly to lower beach	Minor	No	Modest
3 (Significant)	Erosion extends across beach	Can be significant	No	Loss of many structures at local level

4 (Severe)	Severe beach erosion and recession	Severe dune erosion or destruction	On low beaches	Loss of structures at community-scale
5 (Extreme)	Extreme beach erosion	Dunes destroyed over extensive areas	Massive in sheets and channels	Extensive at regional-scale; millions of dollars

Source: North Carolina Division of Emergency Management

Historical Occurrences:

North Carolina's coastline has been impacted by nor'easters and coastal storms on several occasions, primarily due to its proximity to the Gulf Stream. Notable storms include the Ash Wednesday Storm of March 1962 and the Halloween Storm of October 1991. The impact of these storms were concentrated in the immediate coastal areas, as both of these events caused severe beach erosion and eroded roadway segments along North Carolina's Outer Banks.

Not surprisingly, Hyde County has seen its fair share of nor'easters and coastal storms in the past due to its setting along the Atlantic Coast not far from the Gulf Stream. Most recently, on January 27, 1998, Hyde County and surrounding areas suffered through a devastating nor'easter event that was well documented by the National Climatic Data Center. On the morning of the 27th, a major low-pressure system off the southeast coast combined with a strong high-pressure system over New England to produce gale force winds along the coast. Seas between 14 and 18 feet resulted in coastal flooding and lead to major beach erosion problems along the Outer Banks. In Nags Head alone 18 houses were condemned and along the 11-mile stretch of shoreline an average of 45 feet of beach washed away. On Ocracoke Island, N.C. Route 12 was washed over and much of the dune structure on the northern end of the island was washed away. In the wake of the storm some sound-side flooding was reported on Hatteras Island, and heavy rains of up to 5 inches caused lowland flooding and some secondary roads to become impassible. Total damages for the entire region during this event are estimated at 22 million dollars.

Again, on May 06, 2005, the Hyde Emergency Manager reported one to two feet of water over the roadway near Adams Creek. An unseasonable and strong Nor'easter buffeted the North Carolina coast on the 6th with damaging wind gusts, torrential rain, high surf, and coastal flooding. Winds were sustained as high as 45 to 55 mph with wind gusts to 80 mph across coastal counties of Eastern North Carolina. Water levels rose four to six feet above normal along Pamlico Sound, and the lower reaches of the Neuse River. Storm total rainfall amounts ranged from 4 to 7 inches. During the peak of the storm, the Diamond buoy reported 20 foot waves. Moderate beach erosion was reported along the Outer Banks.

In May of 2007, ocean overwash was reported on Ocracoke Island. Some roads were flooded and closed in spots from high water. Strong low pressure developed off the North Carolina coast on May 6th and drifted slowly south of the region on May 7th. Strong high pressure north of the area helped produce a very tight pressure gradient over the region with strong north to northeast winds. The prolonged period of strong northerly winds produced coastal flooding along the Outer Banks and areas adjacent to the southern Pamlico Sound.

1.E. SEVERE WINTER STORMS

Description:

Severe winter storms can produce an array of hazardous weather conditions, including **heavy snow**, **freezing rain and ice pellets**, **high winds** and **extreme cold**. Severe winter storms are usually extra-tropical cyclones (storms that form outside of the warm tropics) fueled by strong temperature gradients and an active upper-level cold jet stream. Winter storms can paralyze a community by shutting down normal day-to-day operations, as accumulating snow and ice result in downed trees, power outages and blocked or hazardous transportation routes. Heavy snow can also lead to the collapse of weak roofs or unstable structures. Frequently the loss of electric power means loss of heat for residents, which poses a significant threat to human life, particularly the elderly.

The level of impact severe winter weather will have upon community greatly depends on its ability to manage and control its effects, such as the rapid mobilization of snow removal equipment. Due to the rare occurrence of severe winter weather in eastern North Carolina, coupled with the expensive costs to acquire and maintain the necessary resources to combat their effects, many communities are not prepared for such events.

Historical Occurrences:

Although severe winter storms are typically associated with much colder climates, it is not uncommon North Carolina to experience significant, even disastrous, winter weather events. Presidential disasters for winter storms were declared in North Carolina in March 1993, January 1996 and February 2000. Since 1993, 16 deaths and 190 injuries have been attributed to snow and ice events throughout the state, along with an estimated 137 million dollars in property damage. In most instances, these impacts are more likely to be felt in the mountains and Piedmont region of the state.

Although Hyde County averages less than 2 inches of snow per year and the temperature rarely drops below freezing, it does experience severe winter storms on occasion. Two recent winter storm events are noted below:

- *February 2, 1996*: An unusual winter storm with snow and freezing rain traversed across the Hyde County region, dumping 2-3 inches except around immediate coastal areas where perhaps an inch accumulated. Temperatures plunged into the single digits, then rose only into the low 20s. Police were kept busy over the weekend with many accidents, and numerous house fires occurred when heating appliances malfunctioned or were used improperly. Schools across the area were closed until highway crews finished treating many of the side streets, which took about 3-4 days. Five deaths and 165 injuries were attributed to the storm along with $310,000 in property damage.

- *January 19, 1998:* Low pressure intensifying off the South Carolina coast produced snow across much of east central North Carolina. Totals ranged from 4 inches in Martin and Pitt counties to a trace along the coast. Numerous accidents were reported as vehicles slid into ditches. A mother and her son were killed in a head-on collision on Highway 264 in Yeatesville (Beaufort County).
- *January 27, 1998:* A major low pressure system off the southeast coast combined with a strong high pressure system over New England to produce gale force winds along the coast. Seas between 14 and 18 foot resulted in coastal flooding and lead to major beach ersosion problems along the Bogue and Outer Banks. The Beach Road in Kill Devil Hills was flooded and 3 piers were partially damaged. Two homes were destroyed. In the wake of the storm some soundside flooding was reported on Hatteras Island. Heavy rains of up to 3 inches caused several rivers including the Neuse and Tar to exceed flood stage and threaten some highways and homes.
- *February 03, 1998:* An intense coastal low moved northeast along the immediate coastline producing strong winds and heavy rain across the region. Seas of 14 to 16 feet ate away at the beaches from Topsail Island to the Outer Banks. In Nags Head alone 18 houses were condemned and along the 11-mile stretch of shoreline an average of 45 feet of beach washed away. Three piers lost pilings and planks and one house fell into the ocean. Damage was estimated at $21.8 million. On the Bogue Banks 15 to 20 feet of dunes washed away destroying beach access walkways. Dune lines were breached in North Topsail threatening a stretch of condominiums. The storm brought 3-5 inches of rain further aggravating already swollen rivers and streams. The Neuse in Kinston rose to 19.5 feet, 5.5 feet above flood stage and the Tar at Greenvile crested over 18 feet. In both cases there was lowland flooding and some secondary roads were impassable. Floodwaters made their way into Belhaven's Town Hall in Beaufort County and other buildings on Main Street. Flooding also occurred in the Whichard's Beach Road area near Washington. N.C. Route 12 on Ocracoke Island was washed over and much of the dune structure on the northern end of the island was washed away.
- *February 17, 1998:* The third coastal storm in less than 3 weeks struck mainly coastal areas from Onslow to Hyde County. Up to 5 inches of rain fell along the coast . Belhaven had almost three feet of water standing in low-lying streets and City Hall was flooded. **A marina in Swan Quarter was flooded**. Large areas of flooding occurred in the Southwest and Bear Creek areas of Onslow County leading to cancellation of school in the county. A 68-foot fishing vessel sank off Cape Lookout with the loss of 4 crewmen.
- *January 3, 2002:* Eastern North Carolina was blanketed by ice and snow beginning later in the afternoon on January 3rd. Snowfall continued for several hours and ended over much of the area by 4am on the 4th. Mainland locations received 4 to 6 inches of snow while along the outer banks only a trace to an inch of snow was recorded from Manteo to Cape Hatteras, mainly due to gusty winds. On the Island of Ocracoke, four inches of snow was recorded within the village.

- *January 23, 2003:* A major winter storm affected eastern North Carolina on January 23, 2003. The storm dumped the highest amounts of snow east of highway 17 across the area known as the Outer Banks, where 8 to 12 inches of snow fell with isolated amounts up to 14 inches, including the counties of eastern Carteret, Dare and, and Hyde counties. This was the largest one day snowfall on the Outer Banks in over a decade. The greatest storm total snowfall occurred on December 23rd and 24th in 1989. Snowfall amounts from 4 to 8 inches fell across central sections of the county warning area including Craven, Pamlico, Beaufort, and Tyrrell counties. Other western counties received 2 to 4 inch snowfall amounts.
- *December 20, 2004:* A winter storm blew through Eastern North Carolina during the early morning hours of the 20th. Winter weather advisories were issued for the entire area. One to three inches of snow was recorded across most of the area. However, a band of snow persisted through mid morning across portions of Beaufort, Pamlico, and eastern Carteret counties producing four to six inches of snow.
- *February 20. 2006:* The first wintry precipitation occurred late in the season across eastern North Carolina during the morning hours on the 20th. Most of the area received a light mixture of wintry precipitation including sleet, snow, and freezing rain. One to two inch snowfall amounts across Outer Banks Dare and Hyde counties resulted in Icy bridges and roads which caused some traffic problems.

1.F. SEVERE THUNDERSTORMS

Description:

Severe thunderstorms are defined by the National Weather Service as storms that have wind speeds of 58 miles per hour or higher, produce hail at least three quarters of an inch in diameter, or produces tornadoes. In order to form, thunderstorms simply require moisture to form clouds and rain, coupled with an unstable mass of warm air that can rise rapidly.

Thunderstorms affect relatively small areas when compared with hurricanes and winter storms, as the average storm is 15 miles in diameter and lasts an average of 30 minutes. Nearly 1,800 thunderstorms are occurring at any moment around the world, however, of the estimated 100,000 thunderstorms that occur each year in the United States only about 10 percent are classified as severe. Thunderstorms are most likely to happen in the spring and summer months and during the afternoon and evening hours, but can occur year-round and at all hours.

Despite their small size, all thunderstorms are dangerous and capable of threatening life and property in localized areas. Every thunderstorm produces **lightning**, which results from the buildup and discharge of electrical energy between positively and negatively charged areas. Each year, lightning is responsible for an average of 93 deaths (more than tornadoes), 300 injuries, and several hundred million dollars in damage to property and forests.

Thunderstorms can also produce large, damaging **hail**, which causes nearly $1 billion in damage to property and crops annually. **Straight-line winds**, which in extreme cases have the potential to exceed 100 miles per hour, are responsible for most thunderstorm wind damage. One type of straight-line wind, the **downburst**, can cause damage equivalent to a strong tornado and can be extremely dangerous to aviation. Thunderstorms are also capable of producing **tornadoes** and heavy rain that can lead to **flash flooding**.

Historical Occurrences:

Severe thunderstorms are very common in North Carolina, but only a small percentage actually cause damages.

According to the National Climatic Data Center, there were a total of 63 severe thunderstorm events in Hyde County during the period of 1950 to June 30, 2008. Of these, only minor damages were recorded - such as downed trees and damaged roofs (these events do not include tornadoes which are discussed in 1.C.). In addition, there were 14 hail events recorded for Hyde County that caused a total of approximately $100,000 in damages. The largest hail officially recorded for Hyde County is 3.5 inches in diameter, which caused $50,000 dollars in property damage and $5,000 in crop damage on May 2, 1995.

1.G. WILDFIRES

Description:

A wildfire is an undesirable, uncontrolled burning of grasslands, brush or woodlands. According to the National Weather Service, more than 100,000 wildfires occur in the United States each year. About 90% of these wildfires are started by humans (i.e., campfires, debris burning, smoking, etc.); the other 10% are started by lightning.

The potential for wildfire depends upon surface fuel characteristics, weather conditions, recent climate conditions, topography and fire behavior. Fuels are anything that fire can and will burn, and are the combustible materials that sustain a wildfire. Typically, this is the most prevalent vegetation in a given area. Weather is one of the most significant factors in determining the severity of wildfires. The intensity of fires and the rate with which they spread is directly rated to the wind speed, temperature and relative humidity. Climatic conditions such as long-term drought also play a major role in the number and intensity of wildfires, and topography is important because the slope and shape of the terrain can change the rate of speed at which fire travels.

There are four major types of wildfires. **Ground fires** burn in natural litter, duff, roots or sometimes high organic soils. Once started they are very difficult to control, and some ground fires may even rekindle after being extinguished. **Surface fires** burn in grasses and low shrubs (up to 4' tall) or in the lower branches of trees. They have the potential to spread rapidly, and the ease of their control depends upon the fuel involved. **Crown fires** burn in the tops of trees, and the ease of their control depends greatly upon wind conditions. **Spotting fires** occur when burning embers are thrown ahead of the main fire, and can be produced by crown fires as well as wind and topographic conditions. Once spotting begins, the fire will be very difficult to control.

Wildfires become significant threats to life and property along what is known as the "wildland/urban interface." The wildland/urban interface is defined as the area where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. Since 1985, approximately 9,000 homes have been lost to urban/wildland interface fires across the United States.

Historical Occurrences:

All of North Carolina is susceptible to wildfire, although according to the North Carolina Division of Emergency Management only the southern coastal plain is said to be at especially "high" risk. Between 1928 and 2008*, the North Carolina Division of Forest Resources has recorded a total of 318,176 wildfires for an average number of 4,028 fires per year. For that same period, a total of 9,776,339 acres have burned for an average of 123,751 acres per year.

According to the North Carolina Division of Emergency Management, Hyde County faces a moderate risk to wildfire. Although wildfires are possible throughout the year, normal fire season peaks for eastern North Carolina are in the Spring and late Fall months.

According to staff within the North Carolina Division of Forest Resources, there is a potential for wildfires to spread quickly in Hyde County due to the nature of its organic soils and the vast amount of forest land. Of the total 392,200 acres in Hyde County, 235,800 are classified as forest land. Of these forest lands, 125,900 acres are privately owned, 35,300 are owned by the timber industry, and 69,300 are owned by the federal or state government.

Most of the fires in Hyde County were caused by burning debris and fortunately were brought under control quickly, and there are no reports of any associated loss of life or property. **Table A-8** provides a five-year summary (2001-2006) of wildfires in Hyde County, according to their cause.

TABLE A-8

Five Year Summary of Wildfires in Hyde County, By Cause	
Cause	**Average Number / 5 years**
Lightning	2.8
Campfire	0
Smoking	1
Debris	3.6
Incendiary	.2
Machine Use	2.2
Railroad	0
Children	0.2
Misc.	0
Total # of Fires	**10**

Source: *North Carolina Division of Forest Resources*

*Data does not reflect the Evans Road Fire 2008 still in progress

1.H. EARTHQUAKES

Description:

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, or the collapse of caverns. Earthquakes can affect hundreds of thousands of square kilometers; cause damage to property measured in the tens of billions of dollars; result in loss of life and injury to hundreds of thousands of persons; and disrupt the social and economic functioning of the affected area.

Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to **ground shaking**. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault, site and regional geology. Other damaging earthquake effects in include **landslides**, the down-slope movement of soil and rock (mountain regions and along hillsides), and **liquefaction**, in which ground soil loses it ability to resist shear and flows much like quick sand. In the case of liquefaction, anything relying on the substrata for support can shift, tilt, rupture, or collapse.

Another dramatic byproduct of certain types of earthquakes is a **tsunami.** Tsunamis are giant ocean waves of extremely long length that are capable of exceeding 500 miles per hour and causing immense devastation to coastal areas. To generate tsunamis, earthquakes must occur underneath or near the ocean, be large and create movements in the sea floor. All oceanic regions of the world can experience tsunamis, but in the Pacific Ocean there is a much more frequent occurrence of large, destructive tsunamis because of the many large earthquakes along the margins of the Pacific Ocean.

Most earthquakes are caused by the release of stresses accumulated as a result of the rupture of rocks along opposing fault planes in the Earth's outer crust. These fault planes are typically found along borders of the earth's ten tectonic plates. These plate borders generally follow the outlines of the continents, with the North American plate following the continental border with the Pacific Ocean in the west, but following the mid-Atlantic trench in the east. As earthquakes occurring in the mid-ocean trench usually pose little threat to humans, the greatest earthquake threat in North America is along the Pacific coast.

The areas of greatest tectonic instability occur at the perimeters of the slowly moving plates, as these locations are subjected to the greatest strains from plates traveling in opposite directions and at different speeds. Deformation along plate boundaries causes strain in the rock and the consequent buildup of stored energy. When the built-up stress exceeds the rocks' strength, a rupture occurs. The rock on both sides of the fracture is snapped, releasing the stored energy and producing seismic waves, generating an earthquake.

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale, an open-ended logarithmic scale that describes the energy release of an earthquake through a measure of shock wave amplitude. Each unit increase in magnitude on the Richter Scale corresponds to a ten-fold increase in wave amplitude, or a 32-fold increase in energy. Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale. It is a twelve-level scale based on direct and indirect measurements of seismic effects. The scale levels are typically described using roman numerals, with a I corresponding to imperceptible (instrumental) events, IV corresponding to moderate (felt by people awake), to XII for catastrophic (total destruction).

A detailed description of the Modified Mercalli Scale of Earthquake Intensity and its correspondence to the Richter Scale is given in **Table A-9**.

TABLE A-9

Modified Mercalli Intensity Scale for Earthquakes			
Scale	**Intensity**	**Description of Effects**	**Corresponding Richter Scale Magnitude**
I	Instrumental	Detected only on seismographs	
II	Feeble	Some people feel it	<4.2

III	Slight	Felt by people resting; like a truck rumbling by	
IV	Moderate	Felt by people walking	
V	Slightly Strong	Sleepers awake; church bells ring	<4.8
VI	Strong	Trees sway; suspended objects swing, objects fall off shelves	<5.4
VII	Very Strong	Mild Alarm; walls crack; plaster falls	<6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged	
IX	Ruinous	Some houses collapse; ground cracks; pipes break open	<6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread	<7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards	<8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves	>8.1

Source: North Carolina Division of Emergency Management

Historical Occurrences:

Earthquakes are relatively infrequent but not uncommon in North Carolina. From 1568 to 1992, 157 earthquakes occurred in North Carolina. The great earthquake of 1811 centered in the Mississippi Valley near New Madrid, Missouri, was felt throughout North Carolina, while Intensity VI effects were observed in the western part of the state. The most property damage in North Carolina ever attributed to an earthquake, however, was caused by the August 31, 1886 Charleston, South Carolina shock. The quake left about 65 people dead in Charleston and led to chimney collapses, fallen plaster and cracked walls in Abbottsburg, Charlotte, Elizabethtown, Henderson, Hillsborough, Raleigh, Waynesville, and Whiteville. On February 21, 1916, the Asheville area was the center for a large intensity VI earthquake, which was felt in Alabama, Georgia, Kentucky, South Carolina, Tennessee, and Virginia - some 518,000 square kilometers in all. Subsequent minor earthquakes have caused damage in North Carolina in 1926, 1928, 1957, 1959, 1971, 1973 and 1976.

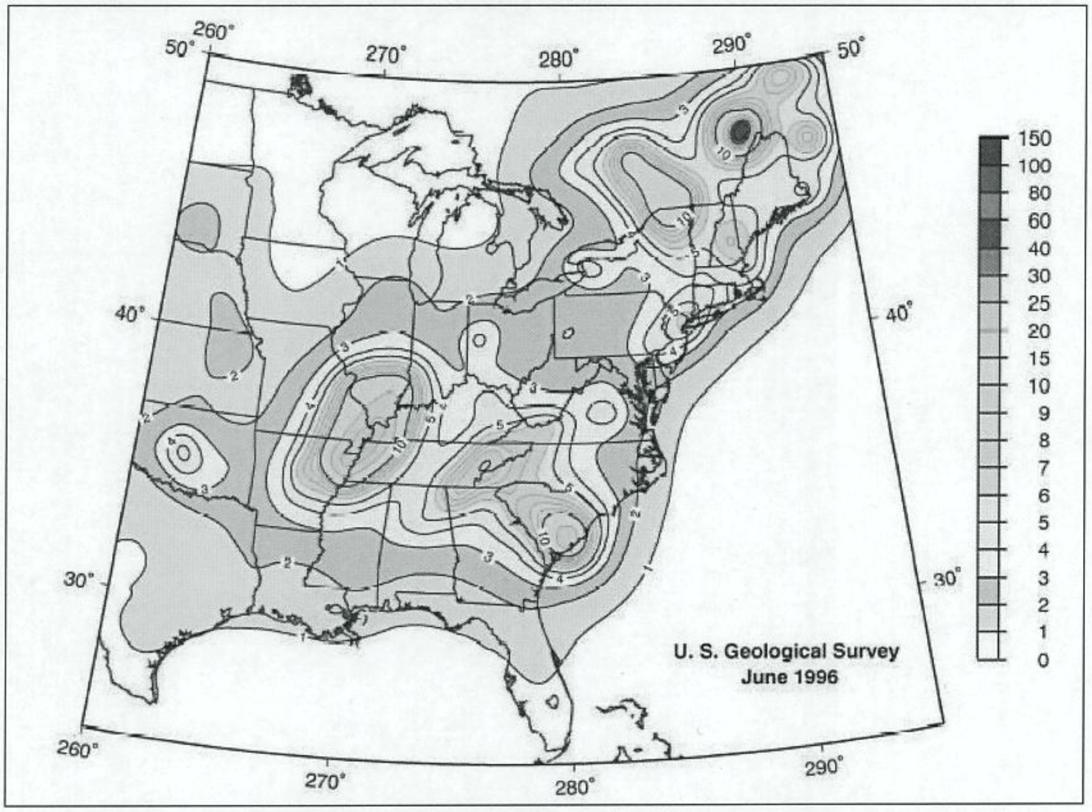
North Carolina's vulnerability to earthquakes decreases from west to east. Earthquake epicenters that affect North Carolina are generally concentrated in the Eastern Tennessee Seismic Zone, which is the second most active zone in the eastern United States only to the New Madrid Fault. Generally, there are three different zones of seismic risk in North Carolina that correspond to different effective peak velocity-related accelerations of ground movement. The eastern portion of the state faces minimal effects from seismic activity. Locations in the middle and southeastern areas of the state face a moderate hazard from seismic activity, while the area from Mecklenburg County west through the Blue Ridge region faces the greatest risk from seismic activity. These different levels of risk correspond to proximity to areas with historical seismic activity and changes in topography.

According to the North Carolina Geological Survey, Hyde County faces a very low risk to earthquakes. There is a recorded 90% chance that any associated ground shaking in Hyde County will cause no damages, and a 98% chance that ground shaking could cause nothing more than light architectural damages. Hyde County is located east of the Suffolk Scarp, which is not a fault scarp, but the geomorphic (land form) expression of the last "high stand" in the transgression and regression of the ocean over the Coastal Plain. The geologic unit at the surface in Hyde County is mainly sand, clay, and gravel from fluvial (river deposited), eolian (wind deposited), or lacustrine (lake deposited) processes. The Quaternary is less than 2 million years old and Hyde County's landscape is still evolving, and as such, wind and water can radically change the physical features of the landscape (i.e.. coastal erosion, overwash, and dune migration).

Hyde County has very little history with earthquakes. While no historical epicenters have been recorded within Hyde County, the area was impacted by the Charleston earthquake of 1886. There are reports of some homes settling or becoming slightly displaced while the ground subsided, and it is quite possible that some chimneys toppled. Of course, this was the most damaging earthquake to occur in the Southeast United States and one of the largest historic shocks in Eastern North America. Structural damage was reported several hundred kilometers from Charleston (including central Alabama, central Ohio, eastern Kentucky, southern Virginia, and western West Virginia), and long-period effects were observed at distances exceeding 1,000 kilometers. It is highly unlikely that Hyde County would be affected by earthquake events other than these extremely rare cases.
Figure A-3 shows the peak acceleration (%g) with 10% Probability of Exceedance in 50 years for the central and east coast of the United States (U.S. Geological Survey, National Seismic Hazard Mapping Project, 1996). Hyde County is located in an area with less than 3%g (peak acceleration), which means it faces very low seismic risk.

FIGURE A-3

Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years



Source: United States Geological Survey

2. HAZARD PROFILE WORKSHEET AND RISK INDEX

The following worksheet has been completed in order to provide a broad profile of each hazard relative to one another. The worksheet classifies each hazard according to their potential magnitude, frequency and impact based upon best available data. The result of this process is the creation of a **risk index**, which establishes numeric ratings for each hazard relative to one another. This index leads to conclusions on hazard risk (Section 3) and forms a basis for concentrating future mitigation efforts as outlined in this plan.

Please note the following with regard to the worksheet:

Magnitude classifications for hurricanes, tornadoes and nor'easters are based upon the accepted intensity scales for each. Other hazards are classified by their maximum potential severity or as otherwise deemed appropriate.

Severe	=	1-10% annual probability with critical impact
Significant	=	10-40% annual probability with critical impact

Frequency classifications are based upon the annual probability for each event, according to the following scale:

Very High	=	70-100% annual probability
High	=	40-70% annual probability
Moderate	=	10-40% annual probability
Low	=	1-10% annual probability
Very Low	=	Less than 1% annual probability

Location classifications are based upon the extent of the jurisdiction affected by the hazard, according to the following scale:

Large	=	More than 50% of jurisdiction affected
Moderate	=	10-25% of jurisdiction affected
Small	=	Less than 10% of jurisdiction affected

Impact classifications are based upon the severity of direct impacts on the area affected, according to the following scale:

Catastrophic	=	Multiple deaths and injuries possible. More than 50% of property in affected area damaged or destroyed. Complete shutdown of facilities for 30 days or more.
Critical	=	Multiple injuries possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of facilities for more than 1 week.
Limited	=	Minor injuries only. More than 10% of property in affected area damaged or destroyed. Complete shutdown of facilities for more than 1 day.

Minor	=	Very few injuries, if any. Only minor property damage and minimal disruption on quality of life. Temporary shutdown of facilities.

Hazard Risk Index Ratings were determined based upon the cumulative analysis of magnitude, frequency, location and impact classifications for each hazard. Risk Index Ratings are based on a scale of **1 (highest risk)** through **4 (lowest risk)**.

Appendix A: Hazard Identification and Analysis

HAZARD	MAGNITUDE	FREQUENCY	LOCATION	IMPACT	HAZARD RISK INDEX RATING
Flooding	10-49 year event	High	Large	Limited	1
	50-100 year event	Moderate	Large	Critical	
	> 100 year event	Low	Large	Critical	
Hurricanes Tropical Storms	Tropical Storm	High	Large	Limited	1
	Category 1	High	Large	Limited	
	Category 2	Moderate	Large	Critical	
	Category 3	Low	Large	Critical	
	Category 4	Low	Large	Catastrophic	
	Category 5	Very Low	Large	Catastrophic	
Nor'easters Coastal Storms	1 (weak)	High	Small	Minor	1
	2 (moderate)	Moderate	Moderate	Limited	
	3 (significant)	Moderate	Moderate	Critical	
	4 (severe)	Low	Moderate	Critical	
	5 (extreme)	Very Low	Large	Catastrophic	

HAZARD	MAGNITUDE	FREQUENCY	LOCATION	IMPACT	HAZARD RISK INDEX RATING
Wildfires	Significant	Moderate	Large	Critical	1
Tornadoes	F0	High	Small	Minor	2
	F1	Moderate	Small	Limited	
	F2	Low	Small	Critical	
	F3	Very Low	Small	Critical	
	F4	Very Low	Moderate	Catastrophic	
	F5	Very Low	Moderate	Catastrophic	
	F6	Very Low	Large	Catastrophic	
Severe Winter Storms	Severe	Moderate	Large	Critical	2
Severe Thunderstorms	Severe	Very High	Small	Minor	3
Earthquakes	Moderate	Very Low	Large	Limited	4

3. CONCLUSIONS ON HAZARD RISK

Based upon the completion of this Hazard Identification & Analysis, each hazard has been classified as high, moderate, low or negligible risk. These classifications will be used as a basis for concentrating and prioritizing future mitigation efforts as outlined in this plan. The risk classifications are presented in **Table A-10**.

TABLE A-10

HIGH RISK HAZARDS	Flooding Hurricanes & Tropical Storms Nor'easters and Coastal Storms Wildfires
MODERATE RISK HAZARDS	Tornadoes Severe Winter Storms
LOW RISK HAZARDS	Severe Thunderstorms*
NEGLIGIBLE HAZARDS	Earthquakes

* Severe thunderstorms are common occurrences in Hyde County, but have been classified as low-risk due to their typically weak intensity. However, this plan does address the more significant and severe effects of thunderstorms (i.e., high winds, flooding, etc.) by aiming to mitigate those effects for other natural hazards such as hurricanes, tornadoes, etc.